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SOVIET PERSPECTIVES ON WEAPONS COSTS

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By understanding the techniques used by the Soviets in their weapons procurement process, it should be easier to explain Soviet decisions that have been made and to predict future decisions.

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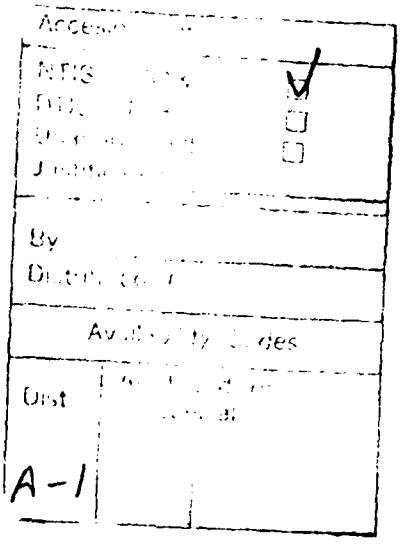

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PREFACE

This IDA Memorandum Report is one of a series of studies prepared for the Strategic Defense Initiative Organization's Countermeasures Office under IDA Task T-R2-344.

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ABSTRACT

This study examines the techniques used by the Soviets to project weapons costs at three stages: research and development; series production; and in use. Projections of research and development costs are based on the labor required; this estimate then serves as the basis for estimating other factors such as overhead and materials. Projections for series production are based on the costs for similar or related weapons already in production. Similarly, projections for operations and maintenance are based on those associated with equipment already in the arsenal.

By understanding the techniques used by the Soviets in their weapons procurement process, it should be easier to explain Soviet decisions that have been made and to predict future decisions.

CONTENTS

EXECUTIVE SUMMARY

According to Soviet theory, cost, effectiveness, and timeliness are the three critical considerations in making military procurement decisions. This study focuses on how costs are defined and used in Soviet decisionmaking, incorporating information from contemporary Soviet sources and emigres previously employed in Soviet military design and production.

Accurate determination of costs is of paramount importance from the very lowest levels of the procurement process. The legal nature of the Plan, which binds the project manager to perform the assigned task to schedule *at the determined cost,* provides incentives for designers to exercise care in their estimations. When the overall cost of a weapon system is calculated, three components are considered: R&D costs, production costs, and use-costs.

Within the R&D community, labor (or wage) costs are regarded as the most reliable basis for estimating total project costs. Total wage calculations, performed on a series of worksheets, incorporate the amount and type of labor necessary at each step of the project. Generally, labor accounts for 35-50 percent of an R&D project's costs, a percentage which seems fairly stable across a range of industrial ministries. Other expenses, including overhead, subcomponents, and raw materials, make up the remainder of itemized expenses and estimated expenditure on them is derived from the initial labor figures.

Estimates of production costs rely on projecting key parameters and analogies. In this process, military specifications, or "tactical-technical characteristics," relate to the cost of previously produced analogous systems. Aircraft costs, for example, are based on the speed and weight of the aircraft. Although this technique seems crude, there is a complex and theoretically sound set of understandings which underpin the methodology. Similar rules of thumb exist for differentiating the changing cost of each copy as series production continues.

Use-costs comprise the obvious costs of physically manning and maintaining equipment. These may comprise a large proportion of a weapon's life-cost. Nevertheless,

calculating such expenditures is fairly straightforward, being based on the present costs of maintaining and using comparable equipment.

In addition, costs must be weighted relative to other factors in Soviet decision-making, and at what level decisions are made. Some of the smallest R&D projects, costing under 500,000 rubles, may be approved by an Institute Director; those over a million rubles must be approved by the Council of Ministers. Questions of cost-effectiveness are directly addressed through "Tactical-Technical Economic Analysis" (TTEA), a continuing process applied at every level of the approval chain from the military services' own Scientific and Technical Councils to the Politburo's Defense Council.

Soviet economic planning affects cost and procurement at several points and in several ways. Resources are allocated to the services early and predictably, according to that service's established missions. If, through the repeated application of TTEA, it is found that a mission-essential system cannot be procured at reasonable cost, the mission itself is reevaluated and the proposed system may be dropped. This interactive loop, and the role of the General Staff as mediator in the process, keep the entire procurement community cost conscious and discourage the services from attempting to use weapons "requirements" to leverage a higher share of the military (or national) budget.

These findings suggest the following implications:

- Mirror imaging may completely obscure any *Soviet* perspective on costs and procurement.
- Given the importance of labor, particularly in R&D cost calculations, studies of Soviet manpower requirements and potential are valuable tools.
- In the realm of production and production decisionmaking, analogies are widely used by the Soviets. Consequently, evidence of Soviet historical predilections about weapons trade-offs, such as those between various types of strategic defense systems, may be valuable in predicting future behavior.
- There are strong incentives not to incorporate "risky" technologies into designs.
- Because the Soviets rely heavily on existing costs in projecting future costs, there is an inherent bias towards incremental development. As a result, major and rapid programmatic shifts are unlikely to occur.

I. INTRODUCTION

This study examines cost as a factor in the Soviet weapons decisionmaking process. It is often suggested that cost plays little role in Soviet weapons decisionmaking, and that the military, because of its priority status, is able to procure whatever it wants. When Soviet weapons costs *are* estimated (for purposes of estimating the Soviet procurement burden, for example) they are often based on cost estimates derived from U.S. models. However, the Congressional mandate that any U.S. strategic defense system be "cost effective at the margin" (that is, that effective Soviet countermeasures should not be cheaper than a U.S. system) and increasing DoD interest in competitive strategies have placed a premium on understanding how the Soviets estimate and view their own weapons costs, rather than relying on western models.

In fact, the costs and benefits of Soviet programs are evaluated inside the Soviet Union based on uniquely Soviet factors and analytic techniques. Military costs are no exception. Soviet leaders rely on internally generated information, much of which is shielded from the public. To help understand their perspective on weapons costs and effectiveness, this study documents the Soviet definition of weapons costs, their techniques for projecting and evaluating the costs of research, development and production, and finally, how costs are weighed in the final selection of weapons systems.

II. HOW THE SOVIETS DEFINE COSTS

There is an important distinction between "costs" and "price" in the Soviet system. Unlike a market economy, in which the price (typically a monetary quantity) is determined by supply and demand and generally reflects the costs (resources used) required to produce an article, prices are set by committee in the Soviet Union. As a result, Soviet prices may or may not reflect actual costs of production.[1] Price thus can depend as much on political decisions as on the availability of resources and level of demand.

According to the *Soviet Military Encyclopedia,* the cost of a weapon is

> the quantity of converted and materialized socially necessary labor in a weapon. It is formed from the cost (*stoimost'*) of the necessary means of production (the expenses of previously materialized labor), the cost of a necessary product, and the cost of surplus products (the cost of living labor). A weapon as an article has not only cost, but also consumer cost, which is expressed in satisfaction with the needs of the army in the means of defense and offense. The size of a weapon's cost is constantly changing.[2]

In other words, the cost of a weapon system is comprised of the cost of raw materials, necessary subcomponents, and labor. This definition covers basically the production cost of the weapon, but, as others have pointed out, "the real cost of a weapon in the scale of the armed forces can be ascertained when taking into consideration the entire, combined social labor expanded to create, maintain, and employ it."[3]

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1 Recent Soviet discussions of the importance of price reform reflect this dichotomy.

2 I.S. Tsygankov, "Stoimost' vooruzheniya" [Cost of Armament] *Sovetskaya voyennaya entsiklopediya,*volume 7, p. 543. Tsygankov is apparently an artillery specialist, having written at least one book and an article on the subject.

3 Colonel B. Kalerin, "Economic Criterion in Research on the Effectiveness of Armament," in *Military Thought,* August 1965. He adds that "in higher military and state planning agencies where economic computations are made not only with the aim of comparing the effectiveness of armament systems, but also of determining the required resources to create them and to introduce them into troop units, the new weapon must be evaluated in complete volume, that is, with a consideration of the expenditures for designing, experimental construction, and the setting up of production." But for analysis within one branch, it is possible to use the basic elements: one-time capital expenditures and maintenance and operations expenditures for life of weapon. And the evaluation of costs over the life (continued)

The first point to recognize is that in the Soviet economy, prices are, in general, bookkeeping conveniences. The price of a product depends more on political decisions than on the availability of resources and level of demand that shape prices in a market economy. A price might be artificially reduced or increased for political reasons. Or the expenses involved in producing an article can be subsidized out of the state budget, rather than through sales alone.

But this does not mean that the *costs* confronting the Soviet planner are artificial; prices are apparently set at the end of the production cycle, while costs must be paid through the production process. Where prices are malleable, costs are not, and in order to estimate a product's costs, the Soviets rely on a number of basic estimating parameters, the principal one being labor costs.

A. RESEARCH AND DEVELOPMENT COSTS

The Soviet economy is planned in considerable detail, and it is not surprising to find that there are equations and estimating techniques for calculating the projected costs of various weapons systems. The Soviets have plans of varying lengths of time, of which the Five-Year is probably the best known. There is also the 20 year Scientific-Technical program, based on inputs from the USSR Academy of Science, the State Committee on Science and Technology, and the State Construction Committee (Gosstroy)[4] and the Ten-Year Draft of the Basic Directions of Economic and Social Development, developed by Gosplan.[5]

The Five Year Plan probably has the greatest impact on research, development, and procurement, for it spells out the available resources as well as the commitments of each

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(continued) of a weapon (capital and operations and maintenance divided by the expected life) allows comparison of weapons systems of comparable effectiveness.

Similar points are made in Maj-Gen Eng A. Parkhomenko, "The Analysis of Armaments Systems," *Military Thought*, number 1, 1968, pp. 33-42.

4 See S.A. Sarkisian and D.E. Starik, *Ekonomika aviatsionnoy promyshlennosti*, 2nd edition (Moscow: Vysshaya shkola, 1985), pp. 106-107; and V.G. Novikov and K.D. Konovalenko, eds., *Organizatsiya i planirovaniye radiotekhnicheskogo proizvodstva* (Khar'kov: Vyshcha Shkola, 1984), p. 225. It seems reasonable to suggest that the Military-Industrial Commission (VPK), responsible for the development and production of Soviet military equipment, also has an input, but this cannot be documented from Soviet sources.

5 See V.G. Novikov and K.D. Konovalenko, eds., *Organizatsiya i planirovaniye radiotekhnicheskogo proizvodstva* (Khar'kov: Vyshcha Shkola, 1984), p. 225.

organization. In turn, the Five Year Plan is broken into annual and quarterly plans, with specific estimates of programs given.

In order to provide input in the development of these plans, the military and civilian laboratories, design bureaus, and industrial plants must have a means of projecting the resources they will need over the coming months and years. It is, of course, difficult to estimate the requirements of research and development (given the uncertainties inherent in the process), but such estimates must be provided. Only after such estimates are provided can serious planning for expenses be undertaken. As one source noted, "an important element in the system of planning activities of a branch NTO [Scientific-Technical Organization] is the fixing of the volume of expenditures necessary for fulfilling all types of work stipulated by the thematic plan."[6]

The Soviets divide research and development into NIR (Scientific Research Work) and OKR (Experimental Design Work). NIR is generally basic theoretical work and OKR is the development of a working design and model of a potential weapons system and its associated documentation. Soviet sources indicate that NIOKR (that is, NIR and OKR, or "Research and Development") *expenditures* are broken up into approximately 25 percent NIR (research) and 75 percent OKR (development).[7]

In proposing research and development on a new weapon system or continuing R&D on an existing one, the designer must develop an estimate *(smeta)* of expenditures *(zatrat)*. In doing so, the Soviets appear to rely on the concept of "labor-consumption" *(trudoemkost')*. The designer begins by providing an estimate of his labor requirements on "Form No. 4." The information included on Form No. 4 becomes the basis for determining how much a project will cost in rubles. It provides a detailed breakdown of the project, including each stage, the labor-consumption (man-days) by type of laborer

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6 *Organizatsiya i planirovaniye deyatel'nosti otraslevykh NII i KB v priborostroyenii* (Moscow: Mashinostroyeniye, 1986), p. 74.

7 See, for example, *Orçanizatsiya i planirovaniye deyatel'nosti otraslevykh NII i KB v priborostroyenii* (Moscow: Mashinostroyeniye, 1986), pp. 43-51. See also S.A. Sarkisian and D.E. Starik, *Ekonomika aviatsionnoy promyshlennosti*, 2nd edition (Moscow: Vysshaya Shkola, 1985), pp. 217-218, where comparable figures are presented for time involved in each stage.

Of the NIR expenditures in the instrument industry, 4 percent is spent on developing the original assignment, 37 percent in choosing the basic direction of the research, 48 percent on theoretical and experimental research, and 11 percent on the evaluation of results. In OKR, 5 percent is spent on developing the proposal, 15 percent in coming up with the draft project, 20 percent on the technical project, and 25 percent on developing the initial design documentation, 30 percent on manufacturing and developing the factory prototype, and 5 percent on state testing and correction of the design documentation before series production.

(scientist at a scientific research institute, designer, worker), and total man-days involved (in one example, the wage for a research scientist was 20 rubles/man-day).[8]

The Soviet designer/planner appears to rely on a basic set of estimating tools for developing the initial *smeta*. The first (and most important) of these is to calculate the number of personnel involved in the project by class of work (basic research, design, drafting, and labor, for example). "The sum of a project's wages is determined by the labor consumption of OKR and the average cost per hour, and then the share of the wages in the cost of the project determine all the expenses on OKR."[9]

The Soviets consider labor costs a reliable base for estimating total research and development costs because they are the basic source of costs in NIOKR. "The proportion of wages in total expenditures on the execution of NIOKR comprises about 50 percent. Analysis of the activities of the scientific-technical organizations of the instrument building industry indicates that the use of labor norms and standards gives the possibility of assigning planned labor consumption of future work with the necessary level of precision; develop planning estimates of expenditures on the undertaking of NIOKR; [etc.]."[10]

According to Anatol Fedoseyev, a leading Soviet ABM radar designer who defected to the west in the early 1970s, the designer estimates how many employees he will need for a particular project. He can then calculate manpower costs in man-days.[11] A recent Soviet source notes that wages comprise 35-50 percent of a project's expenses, and overhead is typically 100-130 percent of the wages.[12] Form No. 5 is used to provide annual ruble estimates by project, type of expenditure, and quarter. The designer also must estimate

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8 *Organizatsiya i planirovaniye deyatel'nosti otraslevykh NII i KB v priborostroyenii* (Moscow: Mashinostroyeniye, 1986), pp. 114-119. The average salary of the Soviet worker is now about 200 rubles per month. See Yu. Rytov, "Semeynyy byudzhet" [The Family Budget], *Izvestiya*, October 10, 1987, p. 1; translated in FBIS, October 14, 1987, pp. 69-70.

There are also several other forms, generally with information derived from that included on Form 4, reprinted in *Organizatsiya i planirovaniye deyatel'nosti otraslevykh NII i KB v priborostroyenii*.

9 S.A. Sarkisian and D.E. Starik, *Ekonomika aviatsionnoy promyshlennosti*, 2nd edition (Moscow: Vysshaya Shkola, 1985), p. 271.

10 *Organizatsiya i planirovaniye deyatel'nosti otraslevykh NII i KB v priborostroyenii* (Moscow: Mashinostroyeniye, 1986), pp. 77-78.

11 Fedoseyev reports that expenses for materials comprise 70 percent to 150 percent of the wages and overhead comes to about 250 percent of wages, although his discussion on these points is sometimes ambiguous. See A. Fedoseyev, *Zapadnya: chelovek i sotsialism*, 2nd edition (Frankfurt: Posev, 1979), pp. 162-168.

12 *Organizatsiya i planirovaniye deyatel'nosti otraslevykh NII i KB v priborostroyenii* (Moscow: Mashinostroyeniye, 1986), pp. 117-119.

how long a project will take, and what proportion of the project will be completed on a quarterly basis.

Of course, the relationship between wages and materials varies with the nature of the project. The development of a "control-measuring instrument", used as an example in one Soviet source, indicates that 6 percent of the development cost was for materials and 32 percent for basic wages. Overhead was 28 percent of the total cost in the example.[13]

Thus, in estimating the basic research and development costs of a new product, the first step the Soviet designer takes is to estimate the manpower and time required. He or she then attempts to "sell" this proposal to the various layers of superiors, in the hope of having it included in the organization's *smeta* for next year.

Projects costing under 500,000 rubles can (at major institutes such as those associated with the Academy of Sciences) be approved by the institute's director. Those costing up to one million rubles are approved at the Academy level, by a deputy minister of a ministry, or by a deputy chairman of a state committee. Those costing over one million are approved by the minister, committee chairman or at the level of the Council of Ministers.[14]

From a scientist's or designer's perspective, there are problems with an institute's reliance on Form No. 4. The approval of the manpower figures in Form No. 4 is not a guarantee that this staff is available or will be provided. Rather, it is funds to pay either new people that might be acquired from the outside or to pay staff already in a facility. The necessary personnel may not be available at the institute or design bureau, and there may be

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13 *Organizatsiya i planirovaniye deyatel'nosti otraslevykh NII i KB v priborostroyenii* (Moscow: Mashinostroyeniye, 1986), pp. 117-119. The remainder went for payments to subcontractors and other miscellaneous expenses.

14 Henry Eric Firdman, *Decision-Making in the Soviet Microelectronics Industry: The Leningrad Design Bureau: A Case Study* (Falls Church, VA: Delphic Associates, 1985), p. 87; The White House, "A Study of Soviet Science," December, 1985, p. 13. Because the Soviets so rarely release information on costs, it is difficult to provide comparable programs and costs. However, the magnitude is hinted at in the annual Military Industrial Commission (VPK) reports on key programs and savings due to the acquisition of western technology. For example, the Ministry of Aviation Industry reported in 1980 that "The economic yield which can essentially be attributed to the borrowing of foreign technical decisions in the different phases of research work and pilot studies is estimated by this ministry at R48.6 million, which is R18.8 million more than in 1978." See "Positive Experience of Foreign Countries," *Le Monde*, March 30, 1985, p. 8, translated in Foreign Broadcast Information Service-Western Europe (FBIS-WE), April 3, 1986, pp. K1-K2. The total saved by the twelve VPK ministries was 317.5 million rubles in 1979 and 407.5 million rubles in 1980. See Philip Hanson, *Soviet Industrial Espionage: Some New Information* (London: Royal Institute of International Affairs, 1987) pp. 30-31.

to husbanding of both manpower and technical resources, for, even if it is not being used at present, it might be needed in the future. The wise designer apparently uses Form No. 4 to obtain manpower and materials for future projects because of the time-delays involved. As Fedoseyev noted, "To rely on equipment supplied in accordance with Form 4 is unrealistic."[15]

The system also gives considerable clout to the financial planning departments, "which understand nothing about science and technology."[16] It makes it possible for a manager to redirect funds away from a project on an annual or quarterly basis, or to require that a program be drawn out for financial reasons.

Providing estimates for research and development thus seems fairly straightforward: the scientist or designer estimates the labor required, by category and by quarter. While it seems simple, such a system also lends itself to over-estimates and to estimating for future (rather than current) consumption.[17] As a result, even internal Soviet cost estimates may be difficult to reconcile with the actual costs of a program. Such a situation is not unlike that found in the United States, suggesting that while the Soviet and U.S. procedures may differ in their specifics, the purposes and results may be quite similar.

B. SERIES PRODUCTION COSTS

Determining the importance of cost in series production is complicated by a number of factors, in particular the maze of mathematical calculations that may or may not be used to measure performance and estimate production costs. In this study, it is only possible to indicate the basic approaches involved.

The first point to recognize is that the size of Soviet defense industrial production is determined externally. In other words, the Ministry of Defense contracts for a set number of a particular item over a set time period (presumably the five year planning cycle is the

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15 Anatol Fedoseyev, "Design in Soviet Military R&D: The Case of Radar Research in Vacuum Electronics," Papers on Soviet Science and Technology #8 (Cambridge, MA: Harvard University Russian Research Center, May 1983), p. 9.

16 Anatol Fedoseyev, *Zapadnya: chelovek i sotsialism*, 2nd edition (Frankfurt: Posev, 1979), p. 165.

17 "Of special difficulty in drawing up the technical assignments [TTZ] were the economic computations, on which the cost of the project and amount of money to be requested from the ministry depended. As a rule, such computations had to be convincing and well-substantiated. However, the requested sum was almost never allocated in full, and in most cases only about 80 percent was financed. Consequently, cost estimates were always inflated to account for the anticipated 20 percent cut." See Karl Greenberg, *The Central Materials Research Institute of the Soviet Ministry of Defense Industry* (Falls Church, VA: Delphic Associates, 1986), p. 60.

base unit of time). Of course, the size of the run is determined in part by cost: 10,000 T-80s could be built in a year, but at enormous cost; producing 1,000 T-80s annually for ten years would presumably prove significantly more cost-effective.

The size of the buy is determined by the Ministry of Defense, the industrial ministry or ministries responsible for production, and (probably) the Council of Ministers' Military Industrial Commission (VPK), which is responsible for coordinating the purchases. Typically, the industrial ministry apparently strives to reshape the number, quality requirements, and schedule of the buy to its benefit while the Ministry of Defense tries to get as much from the ministry in as short a time as possible. For example, a former helicopter designer reported that the Ministry of Defense (apparently advocating a large production run) and the Ministry of Aviation Industry (apparently arguing for a smaller run) present their cases to the Council of Ministers (presumably through the VPK initially[18]) and the Communist Party Central Committee, and that "depending on the international situation and the domestic economy, the aviation industry may receive more or less development funding for the design and production of a new helicopter."[19]

In order to understand how much impact cost has on these critical decisionmakers, it is important to understand how the Soviets estimate the product's cost.

There are several ways to forecast the cost of a manufactured article such as a weapons system, but the clearest (and, apparently, the most commonly used) is based on analogies and key parameters. As one Soviet source noted, "for determining (forecasting) the cost of military technology, heuristic and mathematical (statistical normative) methods, based on established relations between its cost and tactical-technical characteristics, are used."[20]

In the case of aircraft, for example, the estimator calculates the cost based on the weight of the empty aircraft and its speed. The relative importance of these characteristics is determined from empirical data. The projected cost of an aircraft engine is determined in

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18 Fedoseyev reports VPK intervention in resolving general disagreements over designs and procurement. See Anatol Fedoseyev, "Design in Soviet Military R&D: The Case of Radar Research in Vacuum Electronics," Papers on Soviet Science and Technology #8, May 1983, Harvard University Russian Research Center, pp. 13-14.

19 Lev Chaiko, *Helicopter Construction in the USSR* (Falls Church, VA: Delphic Associates, 1985), p. 19.

20 Yu.D. Makiyev and K.A. Nikolayev, "Taktiko-tekhniko-ekonomicheskiy analiz," *Sovetskaya voyennaya entsiklopediya*, volume 7 (Moscow: Voyenizdat, 1980), pp. 635-636, at p. 636. See also Bella Feygin, *The Theory and Practice of Price Formation in the USSR* (Falls Church, VA: Delphic Associates, 1983), p. 74.

the same way, except the characteristics incorporated in the estimate are thrust, pressure, and temperature.[21] Similar "rules of thumb", involving launch costs and payload weight, appear to be used in the development of missiles.[22]

Such a process allows the planners to estimate the cost of producing, for example, the 40th or the 400th aircraft in a series.[23] The first are, as might be expected, at a significantly higher "cost per copy" than subsequent pieces.[24] Thus, a planner should be able to estimate the annual costs for producing a piece of military hardware. This figure, in turn, should be used to determine the resources allocated to the production plant(s) involved and in the contracts between the Ministry of Defense's budget, although this remains a nebulous area.

C. PRICES

There are a number of "prices" *(tsena)* used in the Soviet industrial system.[25] Each plant has an enterprise wholesale price, comprising the production cost and normative profit (generally a fixed percentage), used in "selling" the product to its industrial

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21 The detailed formulae are included in S.A. Sarkisian and D.E.Starik, *Ekonomika aviatsionnoy promyshlennosti*, 2nd edition (Moscow: Vysshaya shkola, 1985), pp. 268-273.

IDA has undertaken considerable work in the past in developing "Cost-Estimating Relationships" (CERs), which are very similar to those apparently used by the Soviet planners. For aircraft, for example, the IDA estimates are based on weight, maximum speed at best altitude, and year of initial operational capability. See Appendix G of James H. Henry et al., *Force and Investment Comparisons of US and USSR Tactical Combat Air Forces*, IDA Paper P-1628 (June, 1982). See also Mark D. Mandeles and Herschel Kanter, *US and USSR Tactical Combat Aircraft Acquisition Measures, 1950-1991*, IDA Memorandum Report M-287 (March, 1987).

22 See V.P. Mishin, ed., *Osnovy proyektirovaniya letatel'nykh apparatov (transportnyye sistemy)* (Moscow: Mashinostroyeniye, 1985), pp. 73-76.

23 There are specific equations given for calculating the cost for the N-th aircraft in a series. See S.A. Sarkisian and D.E.Starik, *Ekonomika aviatsionnoy promyshlennosti*, 2nd edition (Moscow: Vysshaya shkola, 1985), pp. 271-275. For a discussion from the shipbuilding industry, see P.M. Petukhov and L.S. Postnova, *Ekonomika sudostroitel'noy promyshlennosti* (Leningrad: Sudostroyeniye, 1984), pp. 125-126.

24 In the shipbuilding industry, the cost of the first ship in a series is typically 1.5 to 1.8 times that of the tenth ship, for example. It is also apparently customary to charge the set-up costs and initial investments to the first ship, rather than distribute them throughout the series. This may be a function of the relatively long production times of ships. See P.M. Petukhov and L.S. Postnova, *Ekonomika sudostroitel'noy promyshlennosti* (Leningrad: Sudostroyeniye, 1984), p. 126. Whether this takes place in the production of other weapons systems with shorter production times is uncertain.

25 For a very useful discussion, see Morris Bornstein, "Soviet Price Policies," *Soviet Economy*, volume 3, number 2 (1987), pp. 96-134. Also see Paul R. Gregory and Robert C. Stuart, *Soviet Economic Structure and Performance*, 2nd edition (New York: Harper and Row, 1986), pp. 193-202; and Bella Feygin, *The Theory and Practice of Price Formation in the USSR* (Falls Church, VA: Delphic Associates, 1983).

ministry.[26] The industrial wholesale price includes the enterprise price and adds a turn-over tax[27] (see Table 1) and a mark-up. And, of course, there is a retail price on many products.[28]

Table 1. Composition of Prices in the Electronics Industry (early 1980s)

Retail Price	100%	
profit of retail outlet		(1.5%)
expenses of retail outlet		(3.5%)
Industrial Wholesale Price	95%	
profit of industry		(1%)
expenses of industry		(4%)
turn-over tax		(21%)
Enterprise Wholesale Price	69%	
Cost of production		(52%)
enterprise profit		(17%)

Source: P.M. Stukolov, G.M. Lapshin, K.M. Yakuta, *Ekonomika elektronnoy promyshlennosti,* 2nd edition (Moscow: Vysshaya shkola, 1983), p. 89.

When calculating the cost of a piece of military hardware, the Soviets rely on the wholesale price *(optovaya tsena),* that is, the full costs of production *(sebestoimost')* and the plant's normative profit.[29] While the prices are not set by supply and demand, they should reflect the costs of the various components. Thus, the price of an article is

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26 Little is known about profits on weapon systems. It has been reported, however, that the Murmansk Aviation Enterprise received 800,000 rubles profit from two KA-32 helicopters while they were undergoing production tests from December, 1986. See B. Pipiya, "Chto umeyet vertolet," *Pravda,* October 31, 1987, p. 6.

27 One emigre source claims that Soviet weapons are "free from this tax, and hence are often amazingly cheap in rubles compared with consumer goods and services." See Lev Navrozov, "Some Invalid Criticism of the CIA Merits Dunce Cap," *New York City Tribune,* July 22, 1987, p. 2.

It is not clear that Soviet weapons are, in fact, free of the tax, as it is part of the wholesale price. The tax varies as a means for the government to adjust the ultimate price of a product and thus regulate demand. See Paul R. Gregory and Robert C. Stuart, *Soviet Economic Structure and Performance,* third edition (New York: Harper & Row, 1986), p. 197.

28 P.M. Petukhov and L.S. Postnova, *Ekonomika sudostroitel'noy promyshlennosti* (Leningrad: Sudostroyeniye, 1984), pp. 136-138.

29 Yu. D. Makiyev and K.A. Nikolayev, "Taktiko-tekhniko-ekonomicheskiy analiz," *Sovetskaya voyennaya entsiklopediya,* volume 7 (Moscow: Voyenizdat, 1980), pp. 635-636, at p. 636.

independent of its availability (and vice versa). As a result, a scarce component may not be an expensive one. However, the prices are intended to reflect the established costs of production.

The plant proposes a price for a piece of hardware based on its costs and the prices established for any analagous or similar systems (see Figure 1). It recommends this price to the ministry, which, in turn, reviews the price and seeks approval from the State Committee on Prices (Goskomtsen) and presumably Goskomtsen's Department of Prices for Military Equipment. If there is disagreement between the producers, Goskomtsen, and the customer, these are discussed at this time. Goskomtsen's decision after this point is final.

Funds for the fulfillment of the contract may or may not go through the Ministry of Defense. The industrial ministries receive resources from contract sales to the customers (such as the Ministry of Defense) and from the the state budget to cover particular projects.

At this point, it is again necessary to recall that the prices are established by the Goskomtsen, not by supply and demand.[30] The producer plant proposes a price for hardware based on its costs and, if possible, the prices established for an analagous or similar system. It recommends this price to its ministry, which, in turn, reviews the price and seeks approval from Goskomtsen. The ministry also submits the price to the customer (the mechanism by which the MoD actually pays for its purchases is outside the scope of this study). Any disagreement between the producers, Goskomtsen, and the customer are discussed at this time, and Goskomtsen's decision is final.

One of the consequences of this situation is that the user typically has little, if any, impact on price, and thus has little leverage in persuading a producer to satisfy the consumer's requirements.[31] This state of affairs has led to a number of complicated attempts to develop price incentives for the production of high quality goods and new types of products, and for the use of such products.

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30 According to a former senior economist in the State Committee on Pricing, the State Committee has several branch departments, including a Department for Prices for Military Production. See Bella Feygin, *The Theory and Practice of Price Formation in the USSR* (Falls Church, VA: Delphic Associates, 1983), p. 32.

31 See Alec Nove, *The Soviet Economic System*, 2nd edition (London: George Allen and Unwin, 1980), p. 189.

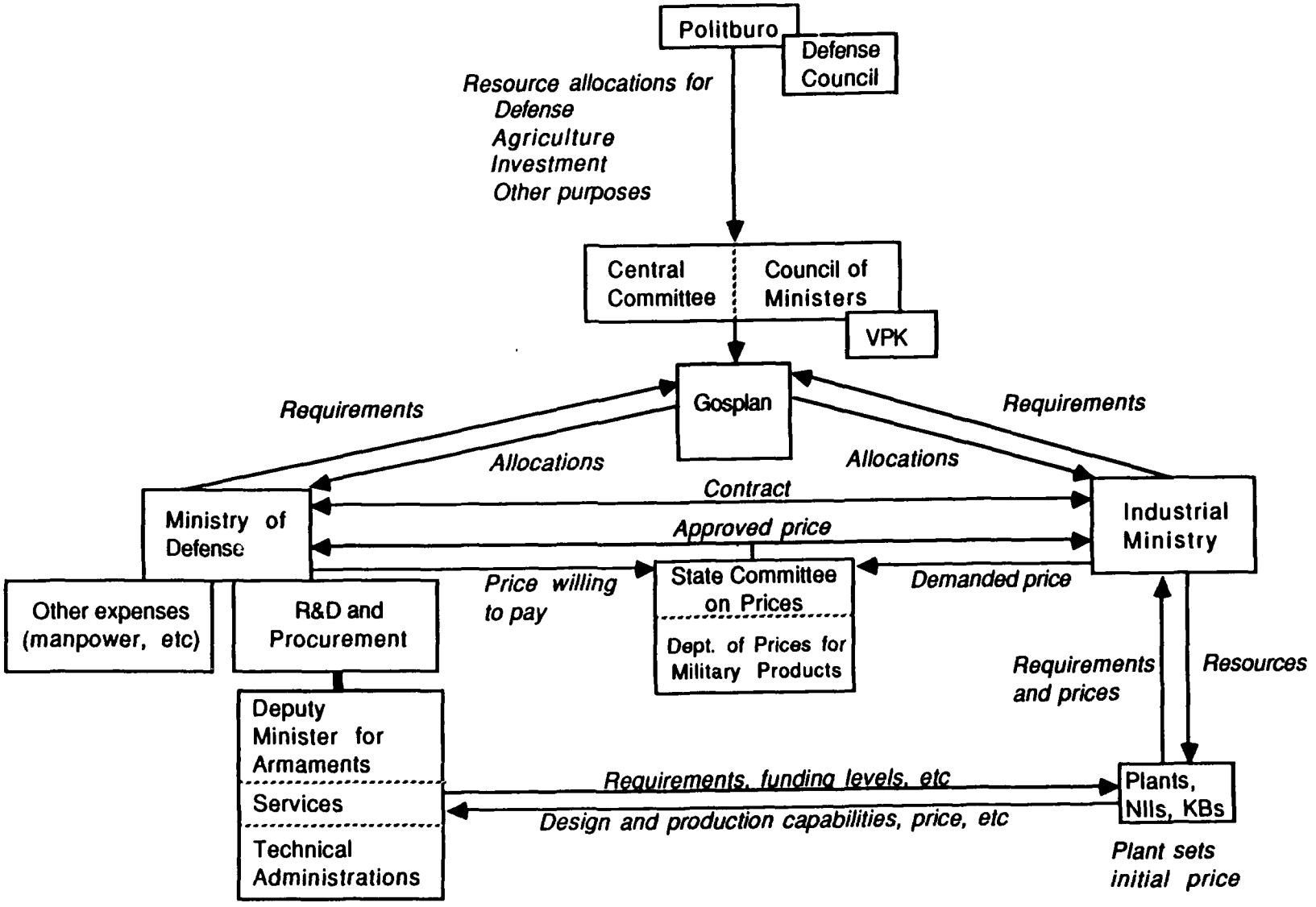

Figure 1. Weapons Price Setting

The paucity of consumer power and influence, especially on quality, is most visible in the case of consumer goods in the Soviet Union. There is little reason to satisfy consumer demand, as it is only marginally relevant to the rewards given a plant or a ministry: the plan, not the consumer, is important. The Ministry of Defense, however, is able to avoid this problem to a considerable degree through the existence of the *voyenpred* (military representative) system at the plants to ensure quality standards and the VPK's role in coordinating and enforcing contracts between the Ministry of Defense and its suppliers. In place of prices and competition between suppliers, military production is shaped by sanctions, administrative measures, and competition with western standards.[32]

D. OPERATIONS AND MAINTENANCE

In evaluating the cost of a weapons system, the Soviets are also quite conscious of the fact that it is not only the cost of the weapon system itself that must be considered, but also the various associated expenses. In estimating expenditures on operations and maintenance, the Soviets rely on their knowledge of current expenditures for operations and maintenance of similar weapons systems. For example, the support personnel and equipment (and the associated costs) for a MiG-31 is likely to be little different from its MiG-25 precursor.

These costs may make up the largest part of a program, which creates an incentive for the Soviets to design their systems to take advantage of existing equipment whenever possible.[33]

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32 While the cost of developing and producing a weapon system is almost certainly knowable within the Soviet system, it is interesting to note that they apparently sell their weapons on the world market at prices pegged to western equipment. See Michael Checinski, "The Costs of Armament Production and the Profitability of Armament Exports in COMECON Countries," Research Paper number 10 (The Hebrew University of Jerusalem: Jerusalem, 1974).

33 See, for example, the discussion in V.P. Mishin, ed., *Osnovy proyektirovaniya letatel'nykh apparatov (transportnyye sistemy)* (Moscow: Mashinostroyeniye, 1985).

III. COSTS AS A CRITERION FOR CHOICE

The Soviets have devoted considerable resources to the planning of their economy, and when choices have to be made, they use the tools which their economy provides and which their political system requires. Choices are shaped by a combination of requirements and costs. This applies to both military and civilian choices.

Cost is only one criterion in the weapons acquisition process. The two others that are probably most significant are time (when a weapon will be available) and effectiveness.[34] In general, cost and effectiveness are the two most frequently examined. The weapon designer and producer are assigned the task of providing maximum effectiveness at a fixed cost or a fixed level of effectiveness for the minimum cost. There are, however, "critical situations" in which the objective is to minimize the time while achieving a predetermined cost and effectiveness.[35]

In undertaking analyses of cost-effectiveness, the Soviets apparently rely on "tactical-technical economic analysis" (*taktiko-tekhniko ekonomicheskiy analiz*, or TTEA). TTEA is defined as

> a complex evaluation of the combat, technical, and exploitable relationship (possibilities) of military equipment and the expenditures necessary for its development and ensured functioning. It is undertaken, as a rule, with the use of "effectiveness-cost" criteria, the essence of which is included in the comparison of the attained combat effectiveness and the expenditures of means needed for these goals.[36]

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34 For a useful discussion of time as a factor, see Robert Pew, *Modeling the Soviet Weapon Acquisition Process*, Greenwood Village: Science Applications, Inc., 1985.

35 See S.A. Sarkisian and D.E. Starik, *Ekonomika aviatsionnoy promyshlennosti*, 2nd edition (Moscow: Vysshaya shkola, 1985), pp. 260-268. The vector optimization techniques Sarkisian and Starik discuss as a means of finding optimal solutions to balancing time, costs, and effectiveness are outside the scope of this study and complex. In fact, most of Sarkisian and Starik's discussion is about problems with vector optimization.

36 Yu.D. Makiyev and K.A. Nikolayev, "Taktiko-tekhniko ekonomicheskiy analiz," *Sovetskaya voyennaya entsiklopediya*, volume 7 (Moscow: Voyenizdat, 1980), pp. 635-636.

"Effectiveness-cost," better known in the West as "cost-effectiveness," has been a Soviet theme for at least two decades.[37] The indicators of combat effectiveness are various indicators of losses inflicted upon the enemy under certain circumstances, the probability of destruction of a target by one shot, the mathematical expectation of the destruction of the area of the target, etc.[38]

Effectiveness criteria are established by the Ministry of Defense, and these are then translated into technical parameters for the suitable weapon system. These technical parameters can be juggled to some extent in the course of design and production, but the interest of the Ministry of Defense is in effectiveness.

The MoD is also responsible for the preparation of the "tactical-technical economic validation" *(taktiko-tekhniko ekonomicheskoye obosnovaniye)*, which analyzes the combat conditions a weapon is likely to face, and compares it with Soviet and foreign weapons and enemy countermeasures. The validation also includes both confirmation that the desired characteristics can be attained and an estimate of the weapon's cost-effectiveness. It is prepared, as a rule, in a military scientific research institute and apparently provided to the relevant technical administration within the Ministry of Defense. It serves as the basis for the initiation of work on a weapon, its acceptance into the arsenal, its modernization, or its removal from the arsenal.[39]

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37 Some of the important books in the field are I. Anureyev and A. Tatarchenko, *Primeneniye matematicheskikh metodov v voyennom dele* (Moscow: Voyenizdat, 1967); Yu.V. Chuyev, *Issledovaniye operatsiy v voyennom dele* (Moscow: Voyenizdat, 1970); K.V. Tarakanov, *Matematika i vooruzhenaya bor'ba* (Moscow: Voyenizdat, 1974); and K.V. Tarakanov, L.A. Ovcharov, and A.N. Tyryshkin, *Analiticheskiye metody issledoniya sistem* (Moscow: Sovetskaya Radio, 1974). The Soviet General Staff journal *Military Thought* also carried a number of articles on the subject of operations research, cost-effectiveness, and weapons acquisition. Perhaps the most interesting was Maj-Gen Eng A. Parkhomenko, "The Analysis of Armaments Systems," *Military Thought*, number 1, 1968, pp. 33-42.

38 Yu.D. Makiyev and K.A. Nikolayev, "Taktiko-tekhniko ekonomicheskiy analiz," *Sovetskaya voyennaya entsiklopediya*, volume 7 (Moscow: Voyenizdat, 1980), pp. 635-636.

39 "Taktiko-tekhniko ekonomicheskoye obosnovaniye," ("Tactical-technical Economic Validation"), *Sovetskaya voyennaya entsiklopediya*, volume 7 (Moscow: Voyenizdat, 1980), p. 636.

IV. COST IN THE DECISIONMAKING PROCESS

Cost plays an important, perhaps determining role at each level of the Soviet weapons research, development, and procurement process. The process itself, however, affects the application of costing and cost-effectiveness methodologies. Formally, cost and effectiveness are aggregated differently at each level of analysis. Additionally, there are informal effects--which are not necessarily incidental or unplanned: the legal and analytical framework of long-term planning places unique pressures on each organization that supplies documentation or conducts analysis. The timing embedded in the sequence of events and the technical resources available to each party define the scope of analysis and determine the importance and independence of each evaluation. This section briefly examines the general nature and sequence of the procurement process.

The Soviet military procurement process is highly regimented. Each proposed weapon system passes through a series of standard feasibility, research, development, and production phases. Apparently, between each stage the proposed system or group of systems undergoes Tactical-Technical Economic Analysis (TTEA), and a decision is reached on whether the item's progress should be continued. It is during these evaluations that cost-effectiveness is determined. For example, an air-to-air missile may be cost-effective, but is the aircraft that carries it? Even if these two pieces of equipment are cost-effective, are they cost-effective when one includes the required basing and support structure? Are they more cost effective or more necessary than alternative solutions to the same problem (for example, surface-to-air missiles)? And which weapon is likely to remain cost-effective for a longer period of time?

Despite the apparent regimentation, it should be noted that each time a TTEA is conducted, new data, where available, are substituted for the estimates or old data, progressively eliminating elements of uncertainty in the equation during each iteration. The method of analysis remains the same, if the level and scope does not. Moreover, several key organizations and players become involved in procurement decisions early in the process and remain involved thereafter. The continuous nature of TTEA and the closed circle of actors makes planning and evaluation resemble more of an interactive loop than a

series of separate and distinctive analytical nodes. This process of reevaluation is captured in Figure 2, showing how the missions are altered when the already allocated resources are insufficient.[40]

Resource division is generally allocated among the military services based on the importance of the mission or tasks assigned to that service. This broad resource allocation is generally predictable well before final budgets are decided.[41] There is seldom wide fluctuation in service budgets from year to year.[42] This has several implications. Systems are evaluated by the services as cost-effective or not cost-effective based on their contribution to the accomplishment of assigned mission, not based on narrow performance parameters (although these obviously are an important part of the equation). Weapon designs and concepts cannot be "used" by the services to compete for a larger share of total military allocations, as is often the case in Western procurement.[43] Having resources thus "set" for him, the service chief is likely to view cost as a primary consideration in his planning.[44] Calculated cost cutting would allow a service chief to support a larger force structure.[45] The same logic would dissuade military acquisition planners from launching crash programs, which result in smaller procurement levels overall.

Mission orientation is reflected in the description of TTEA:

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40 B. Makeyev, "Nekotoryye vzglyady na teoriyu vooruzheniya VMF" [Some Views on the Theory of Armaments of the Navy], *Morskoy sbornik*, number 4, 1982, pp. 27-31, at p. 28.

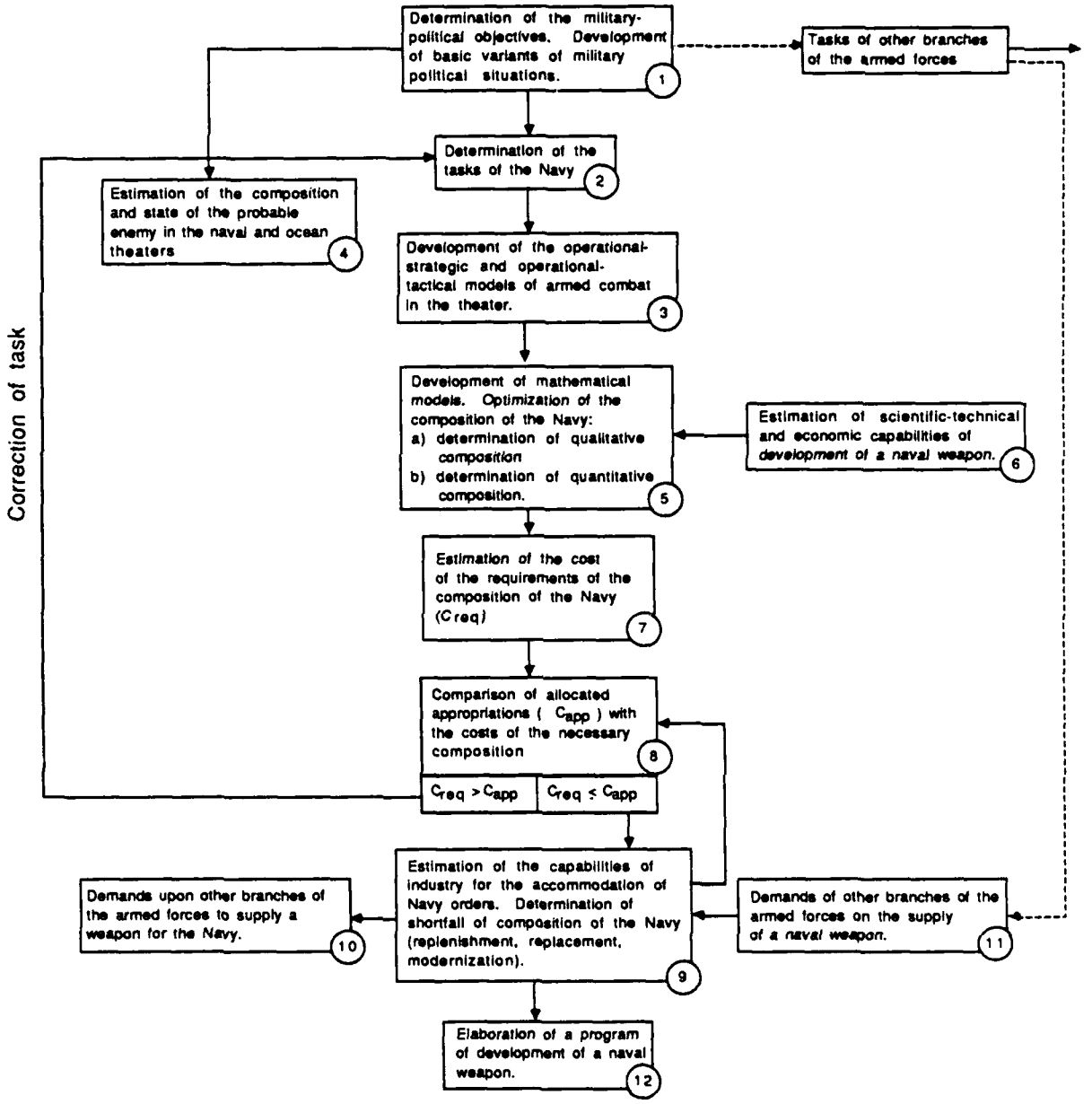
41 According to one former Soviet economist, from the beginning of the annual planning process the political (i.e. Party) leadership fixes the control figures (the initial plan proposed by Gosplan to ministries for review and adjustment) so that each department is well aware of the resources at its disposal when it helps the ministry with its planning. See Fyodor I. Kushnirsky, *Soviet Economic Planning, 1965-1980* (Boulder, Colorado: Westview, 1982).

42 Michael MccGwire has remarked on the stability of naval budgets and production. See his "Western and Soviet Naval Building Programmes, 1965-1976," *Survival*, volume 18, number 5 (September/October, 1976), pp. 204-209. Occasionally, major strategic reevaluations do shift budgeting significantly, as when Khrushchev adjusted budgets to concentrate on strategic arms. Referring to the United States, Solnyshkov portrays optimization as impossible in situations where service budgets are not set early and predictably. Yu.S. Solnyshkov, *Optimizatsiya vybora vooruzheniya* (Moscow: Voyenizdat, 1968), p. 95.

43 This form of budget allocation makes inter-service rivalries manifest themselves in debates over the mission assignments themselves, as when Gorshkov argued for a larger role for the Navy or the debate in the late 1950s and early 1960s over the relative importance of missiles and aircraft.

44 It might be tempting for a service chief to cut into current operations and maintenance to reallocate funds to procurement. If this is ever done and how it might be accomplished is, however, unclear, and outside the scope of this study.

45 This might explain the roughness of Soviet tank welding or the relative lack of "trimmings" on aircraft. There is little doubt that the Soviets could add such items; they probably know precisely how many rubles "roughness" saves on every item.



Source: B. Makeyev, "Nekotoryye vzglyady na teoriyu vooruzheniya VMF," Morskoy sbornik, number 4, 1982, p. 28.

Figure 2. Soviet View of Weapons Acquisition Process

> In particular cases, cost criteria of the TTEA can be: the cost of the carrying out of combat task; the cost of groups designated for carrying out the combat task; the cost of losses of means due to the carrying out of the combat task; the cost of a shot (launch), etc.[46]

Weapons are evaluated as part of 'combined arms' teams. First, the weapons options are indicated by the service(s) and parameters or required norms are assigned. For example, if the mission is the air defense of an armored division, existing and potential high-, medium-, and low-altitude missiles and guns will be identified, together with their estimated capabilities and cost. Next, the various combinations of systems are evaluated using operations research to achieve the maximum effectiveness with fixed resources. Once the 'best' combination is identified, the debate on the various options is not reopened (in theory) farther up the decisionmaking chain.

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46 Yu. D. Makiyev and K.A. Nikolayev, "Taktiko-tekhniko ekonomicheskiy analiz," *Sovetskaya voyennaya entsiklopediya*, volume 7 (Moscow: Voyenizdat, 1980), pp. 635-636.

V. CONCLUSIONS

To Soviet planners, the cost of a weapons system is comprised mainly of the cost of raw materials, necessary subcomponents, and labor. Labor, generally totaling 35-50 percent of a project's research and development costs, is the most important variable in making cost projections for the Soviet designer. The ruble cost of the labor required, once estimated, is the basis for projecting the costs of overhead and required materials, and together these determine the total projected cost of research and development of a new weapon or weapon system. The labor costs themselves are weighted by the nature of the work undertaken (basic research, design work or engineering, labor, etc.).

During research and development, it appears that about 25 percent of a project's expenditures is taken up by more basic research (that is, determining the direction of research, theoretical and experimental research, and evaluation) and 75 percent on development (developing the draft and technical projects, design documentation, producing one or more prototypes, and testing).

Each projected stage and cost of a project is documented on an annual, quarterly, and monthly basis by the designer on worksheets. The more expensive the project, the higher up the administrative hierarchy it must go for approval.

The Soviet decisionmaker also needs to have projections of costs for production of a new weapon system or variant. Such projections are generally based on analogies with existing systems and/or mathematical relationships between an existing weapon's cost and its "tactical-technical characteristics" such as speed or weight.

When evaluating the final cost of a weapon, the Soviets use the wholesale price, that is, the cost of production and the plant's planned profit.

Cost is only one criterion by which weapon acquisition choices are evaluated. The two others which are most significant are time and effectiveness. Under some circumstances, a weapon's timely acquisition may be critical, while in other cases a minimum standard of effectiveness will be the overriding concern. In calculating the effectiveness of a weapon system, the Soviets use indicators such as losses inflicted on an

enemy or the mathematical probability of a target's destruction. Cost, effectiveness, and timeliness are juggled in the process of Tactical-Technical Economic Analysis (TTEA). The continuing TTEA process and the relatively closed circles of actors involved make planning and evaluation a closed loop.

Finally, resources on the large scale are allocated relatively early in the process; the situation is one of capabilities accommodating resources, rather than unlimited resources being made available. The Soviets have traditionally emphasized a "combined arms" and all-services approach in satisfying mission requirements, and the early and predictable allocation of resources and a strong General Staff integrating service agendas reinforce these themes.

There are several implications of these findings. The first is to emphasize again the limitations of any analysis based on "mirror-imaging" or analyses based on dollar costs. Frequently, one encounters analysis of Soviet military and/or political decisionmaking which is based on dollar-costs or which assumes that the relative costs of a program are roughly comparable between the U.S. and the Soviet Union. In fact, the problem is much more complex: for example, the relative low pay of the Soviet armed forces makes manower-intensive solutions more attractive than those based on technology, and the Soviets apparently do not think of the defense burden the way the U.S. does, or keep records in the same ways. As a result, mirror-imaging (in which we assume they make cost decisions the same way that the U.S. does) is risky. If we wish to explain Soviet decisions about, for example, their continued dedication to a seemingly non-cost-effective strategic defense system it is helpful to understand *their* understanding of that system's costs, rather than imposing our own on it.

In contrast, studies of scientific and production manpower issues could prove very valuable, providing insights into a range of Soviet weapons R&D issues. Questions to be addressed could include: how important are trained personnel in the weapons cycle, how well does the Soviet system provide them, and how productive are they?

The techniques regularly used by Soviet scientists and designers to project and obtain funding for projects also shape the weapons which are, in fact, procured. The rigidity of the process helps explain the incrementalism apparent in Soviet weapons procurement. It is easier to obtain funds for a weapon system similar to, or built upon, one which already exists. As a result, the designer or scientist is likely to propose low-risk projects. Even if a designer attempts to promote innovative proposals or radical departures

from existing programs, such proposals are much less likely to receive easy approval: given limited funds, a Ministry of Defense official is likely to place his rubles where they will achieve definite, if marginal, improvements over a riskier investment. In addition, all involved are interested in using existing facilities and equipment whenever possible, not only to keep costs down, but also because of the easy assimilation into the existing force structure and the demonstrated reliability of derivative products.

As a result, evidence of Soviet historical predilections about weapons trade-offs, such as the those between various types of strategic defense systems, may be very valuable in predicting future weapons choices.

Finally, an implication of Soviet reliance on such techniques is that unless the state is faced with a significant new threat, the Soviet system does little to support the development of major technological surprises and much to minimize them.

Costs are clearly a critical determinant in Soviet weapons choices. While the details of these choices are almost always obscure, an understanding of the techniques used by the Soviets to project weapons costs, coupled with an understanding of how the Soviets make their procurement decisions, will make it easier both to predict and to interpret Soviet military acquisition.